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■

2006 Fish Salvage at the State Water Project and Central Valley Project Fish Facilities.

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Introduction

The Tracy Fish Collection Facility (TFCF) and the Skinner Delta Fish Protective Facility (SDFPF) divert (salvage) fish from water exported from the Sacramento-San Joaquin Estuary. The TFCF began operation in 1957 and the SDFPF began operation in 1967 with both facilities using a louver-bypass system to salvage fish from the exported water. The salvaged fish are returned to the San Francisco Estuary by loading the salvaged fish into tanker trucks and trucking them to predetermined release sites.

This report summarizes salvage information from the TFCF and the SDFPF in 2006. The following species are given individual consideration: Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), striped bass[1] (*Morone saxatilis*), American shad (*Alosa sapidissima*), longfin smelt[1] (*Spirinchus thaleichthys*), delta smelt[1] (*Hypomesus transpacificus*), inland silversides (*Menidia beryllina*), threadfin shad[1] [1](*Dorosoma petenense*), splittail (*Pogonichthys macrolepidotus*), green sturgeon (*Acipenser medirostris*), white sturgeon (*A. transmontanus*), common carp (*Cyprinus carpio*), and Chinese mitten crab (*Eriocheir sinensis*).

Methods

The daily volume of water exported was reported from gauge readings from the Jones Pumping Plant (Central Valley Project, CVP) and the Harvey O. Banks Pumping Plant (State Water Project, SWP). Monthly water exports were calculated as the sum of daily measurements, rounded to the nearest 0.1 million m^3, plotted, and examined for time trends. Annual exports were determined from 1993 – 2006 and rounded to the nearest 0.1 billion m^3. Water temperature was recorded during routine fish counts at both the TFCF and the SDFPF. Daily mean water temperature was calculated and examined for time trends during 2006.

Abundance of fish or mitten crabs was reported in terms of estimated salvage. Only fish that are greater than 20 mm in length were numerated (counts) as the salvage efficiency of each facility drops off rapidly for fish less than this size. Salvage estimates are primarily obtained by expanding the routine sample counts for the given time that water was pumped using the following equation:

$$SALVAGE_{SAMPLE} = COUNT_{SAMPLE} \mathbf{x} (MINUTES\ PUMPING / MINUTES_{SAMPLE}). \quad (1)$$

Fish collected from predator removals are not expanded:

$$SALVAGE_{PREDAROR\ REMOVAL/SECONDARY\ FLUSH} = COUNT_{PREDAROR\ REMOVAL/SECONDARY\ FLUSH.} \quad (2)$$

Monthly or annual salvage estimates were calculated by the summation of Equations (1) and (2) by month or year. Intra-annual abundance was examined by plotting the monthly salvage totals for selected species and for all taxa combined for 2006. Relative abundance among years was analyzed by graphing the annual salvages for selected species/all taxa combined from 1981-2006. The prevalent species in salvage were determined by ranking the annual salvage totals in descending order with the 5 most prevalent species identified.

The annual and monthly salvage estimates for Chinook salmon and steelhead were subcategorized as wild, hatchery or fish of unknown origin. Salmonids of wild or hatchery origin were determined by the presence (wild) or absence (hatchery) of adipose fins. The race of Chinook salmon was classified by the Delta Salmon Length-Race Key using body size and date of capture information. Salmonids were recorded as unknown race or origin when the count observations were insufficient to categorize their status.

Fish loss was reported for Chinook salmon only since key loss information is lacking for other species. Loss is the difference between the estimated number of fish encountered by the facility and the fish that survive salvage operations; these values were determined experimentally and are applied whenever Chinook salmon salvage occurs. Loss was subcategorized by origin and race.

1. Pelagic Organism Decline (POD) species

Length measurements were taken systematically during fish counts to determine the size of fish and mitten crabs. The annual minimum, maximum, and mean lengths measurements were calculated for all selected species. Fork length (FL) was measured for all species except for sturgeon (*Acipenser spp.*) and mitten crabs where total length (TL) or carapace width was reported respectively.

Statistical testing was conducted to determine if there was a significant difference in size of fish salvaged between the 2 facilities or their origins (e.g., wild vs hatchery). Testing consisted of using 2 sample t-tests run under SAS using PROC TTEST (SAS Institute, Inc, 1989). Calculated concurrently and run with the 2-sample t-test was a folded form F statistic analysis to test the assumption that the variances from both samples were equal (SAS Institute, Inc, 1989). If the result of this test was significant, the length data were transformed using natural logarithms (Ramsey and Schaffer 2002) and retested.

Given the size and scope of this report, more elaborate analysis and testing of the size of fish salvaged was not attempted.

Exports and Water Temperature

Annual exports were within the range of exports in recent years (2002 – 2005; Figure 1). The SWP exported roughly 4.3 billion m^3 of water in 2006; in range with recent annual exports that ranged from 3.4 -5.0 billion m^3 (Figure 1). The CVP exported roughly 3.2 billion m^3 of water in 2006; in the range of recent exports that ranged from 3.1 – 3.4 billion m^3.

The majority of water exported in 2006 occurred from June to December (Figure 2). State Water Project monthly exports ranged from 144.4 – 539.1 million m^3 of water (Figure 2). From June to December, 3.2 billion m^3 of water was exported, accounting for 74% of the 2006 annual export. Central Valley Project exports ranged from 59.8 – 333.5 million m^3 of water (Figure 2). From June – December, 2.2 billion m^3 of water was exported, accounting for 69% of the 2006 annual export.

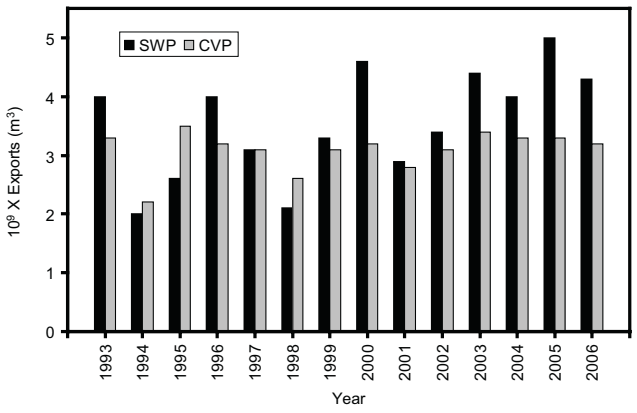

Figure 1 Annual exports in billions of cubic meters for the SWP and the CVP, 1993 - 2006

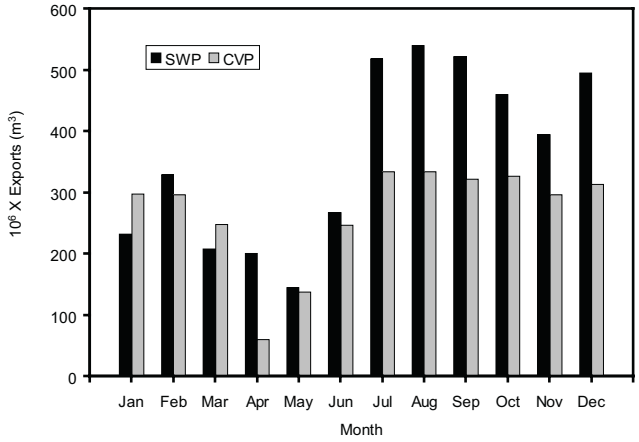

Figure 2 Monthly exports in millions of cubic meters for the SWP and the CVP in 2006

Differences in mean daily water temperature (temperature) between SDFPF and TFCF were most prevalent in the first half of the year (Figure 3). Temperature at SDFPF ranged from 7.8 – 29.4 °C. Temperature at TFCF ranged from 7.9 – 28.6 °C. The temporal pattern of temperature at both facilities followed a typical pattern of increasing from January to July and decreasing there after (Figure 3). Given the close proximity of the 2 facilities, it is reasonable to expect that the temperatures at the each facility would closely track one another. However, the temperature at SDFPF was frequently 2 and occasionally 5 degrees lower than that at TFCF during the first part of the year; most notably from mid-May – mid-June (Figure 3). After June, the temperatures at the 2 facilities very closely correlated (Figure 3).

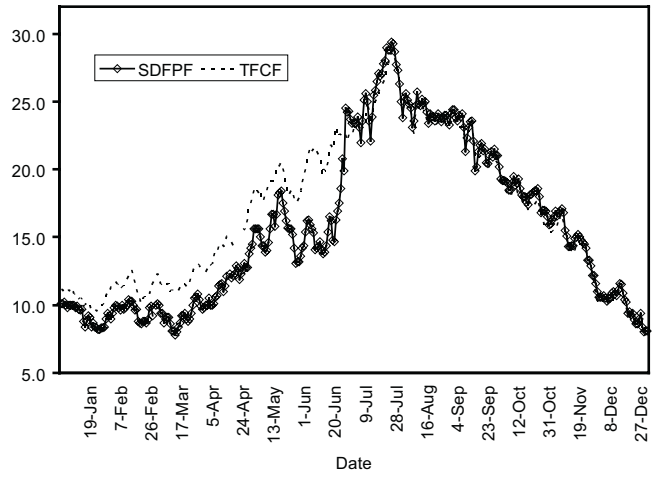

Figure 3 Daily mean water temperature at the SDFPF and the TFCF for 2006

Total Salvage and Prevalent Species

Annual combined salvage (annual, all species salvage) in 2006 at the TFCF, 37,266,449 was a record high for the period of record, regardless of facility. Generally, annual salvage values were below 10 million/year (Figure 4). However the 2006 annual salvage at TFCF dwarfs any previous value and represents an order of magnitude increase from the TFCF annual salvage in 2005 (2,430,642). This is in stark contrast to the modest increase in annual salvage at the SDFPF, from 3,019,512 in 2005 to 5,138,458 in 2006. The next highest annual salvages were at the SDFPF in 1986 and 1993; in both cases, slightly below 18 million (Figure 4).

The annual salvage at both facilities was dominated by carp. At the TFCF, carp accounted for 81.8% of the annual salvage. The only other species to be salvaged in comparable numbers at the TFCF was splittail (Figure 5). The situation was less lopsided at SDFPF where carp accounted for 53.3% of the annual salvage. The other species that occurred in comparable numbers at SDFPF were threadfin shad, American shad, and splittail (Figure 6). These 4 species accounted for 89.6% of the annual salvage at SDFPF. Generally, threadfin shad has made up the bulk of salvage at both facilities, especially in later years (Figures 7 and 8). Large occurrences of carp and splittail have also occurred only in 1995 and 1998 (Figures 7 and 8). Therefore, the domination of salvage by carp and splittail may be ephemeral and is suggested by the "boom and bust" nature of splittail salvage (see below).

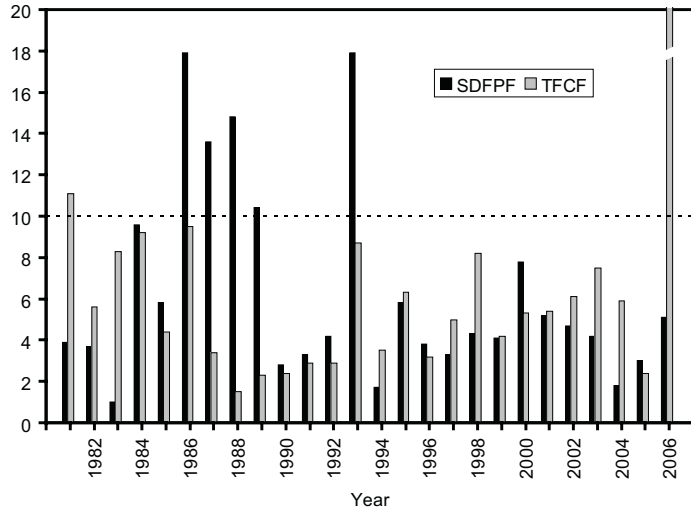

Figure 4 Annual salvage of all taxa combined at the SDFPF and the TFCF, 1981 - 2006. The TFCF 2006 annual salvage of 37.3 million has been truncated for scale considerations

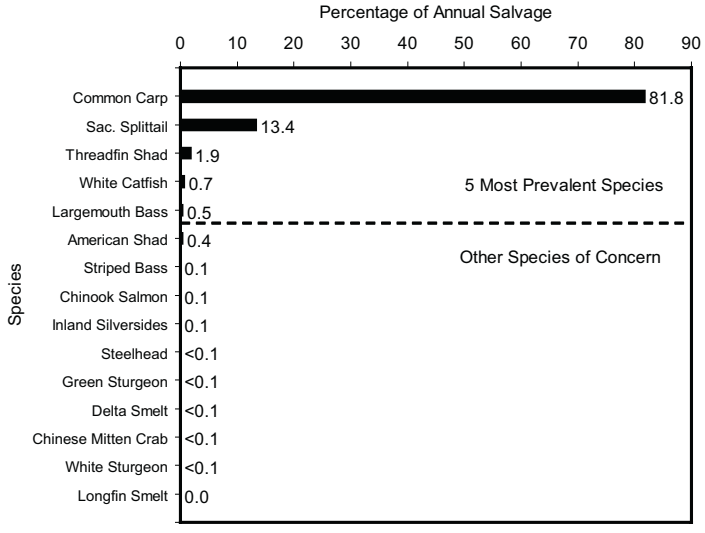

Figure 5 Percentages of annual salvage for the 5 most prevalent species and species of special interest at the TFCF, 2006

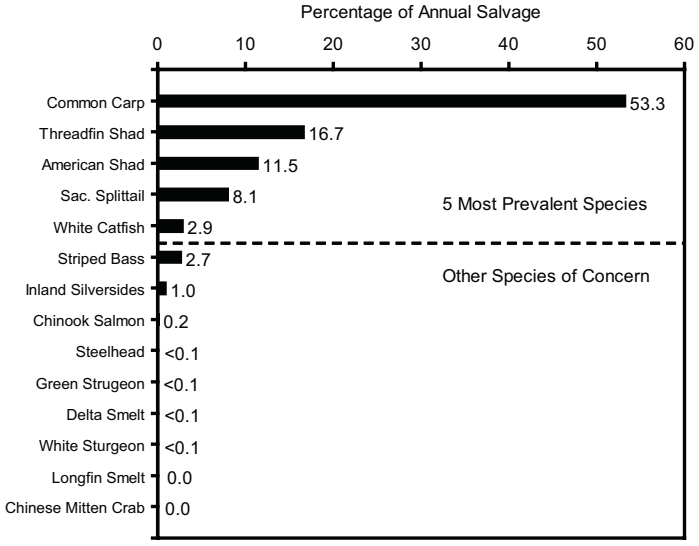

Figure 6 Percentages of annual salvage for the 5 most prevalent species and species of special interest at the SDFPF, 2006

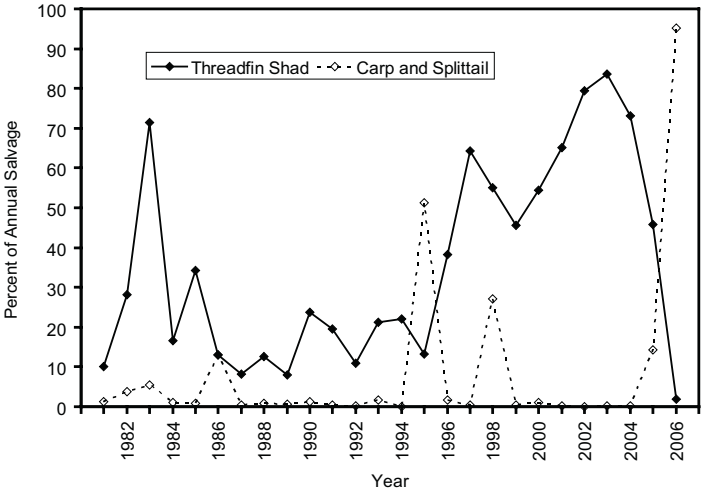

Figure 7 Percentages of annual salvage represented by threadfin shad and carp+splittail at the TFCF, 1981 - 2006

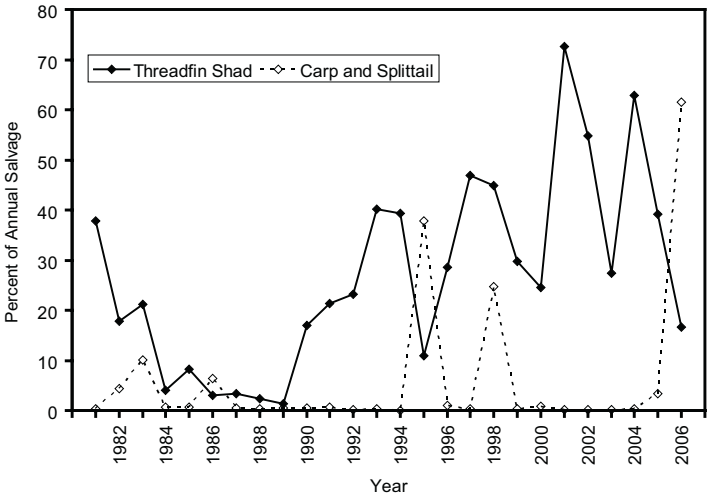

Figure 8 Percentages of annual salvage represented by threadfin shad and carp+splittail at the SDFPF, 1981 - 2006

The month of June accounted for the majority of the 2006 annual salvage at both facilities (Figure 9). At the SDFPF, the June salvage of 3,017,683 accounted for 59% of the 2006 annual salvage. At the TFCF, the June salvage of 34,913,860 accounted for 94% of the 2006 annual salvage. Salvage from January – April accounted for a very small faction of annual salvage at each facility (Figure 9).

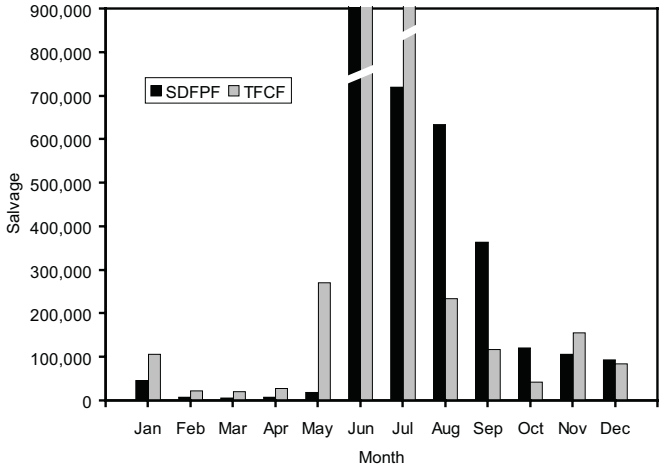

Figure 9 Monthly salvage of all taxa combined at the SDFPF and the TFCF, 2006. The June salvage (3,017,683) at the SDFPF has been truncated for scale considerations. The June salvage (34,913,860) and the July salvage (1,276,708) at the TFCF have been truncated for scale considerations.

Chinook Salmon

Annual salvage (all races and origins combined) of Chinook salmon continued to be low at both facilities with higher salvage at the TFCF than at the SDFPF (Figure 10). The annual salvage of salmon at the SDFPF in 2006, 8,629, decreased from the annual salvage of 13,065 observed in 2005, continuing the slight declining trend that started in 2003 (with the exception of 2005, Figure 10). The annual salvage of salmon at the TFCF in 2006, 35,319, was an increase from the annual salvage of 25,637 observed in 2005 and continuing the slight increasing trend that started in 2002 (Figure 10). However, these annual salvages are dwarfed by annual salvages observed in the 1980's and the late 1990's (Figure 10).

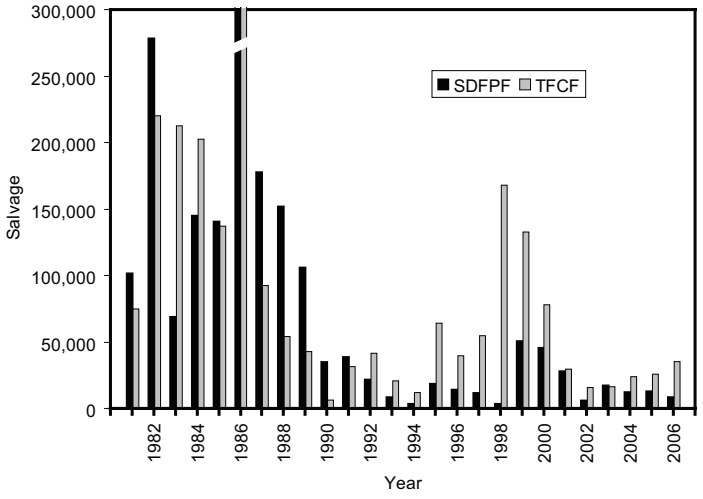

Figure 10 Annual salvage of Chinook salmon (all races and origins combined) at the SDFPF and the TFCF, 1981 - 2006. The SDFPF 1986 salvage of 435,233 and the TFCF 1986 salvage of 752,039 have been truncated for scale considerations.

Salvage of Chinook salmon at both facilities was composed primarily of wild, fall run fish followed wild, spring run fish (Table 1) with the majority of salvage occurring in a narrow time frame. Wild fall run fish comprised 63% of the annual salvage at the SDFPF and 82% of the annual salvage at the TFCF. Wild spring run fish comprised 27% of the annual salvage at the SDFPF and 10% of the annual salvage at the TFCF. The majority of wild fall run fish, 88% at the SDFPF and 83% at the TFCF, were salvaged in June (Figure 11). The majority, 78%, of wild spring run fish salvage at the SDFPF were salvaged in April (Figure 12). At the TFCF the majority of wild spring run salvage, 69%, occurred in May (Figure 12).

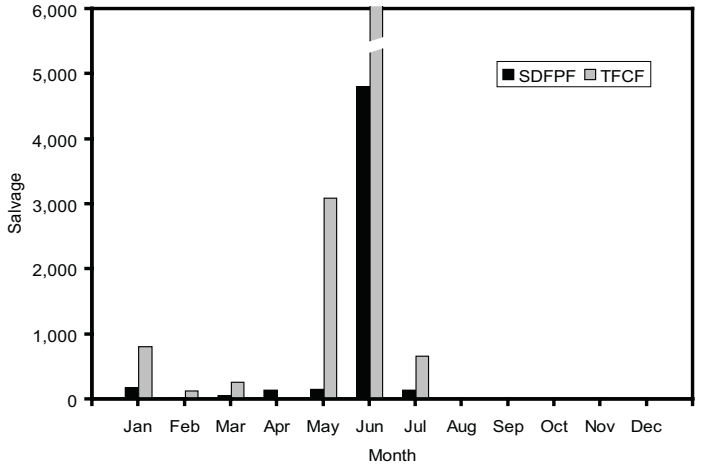

Figure 11 Monthly salvage of wild, fall run Chinook salmon at the SDFPF and the TFCF, 2006. The June salvage of 23,928 at the TFCF has been truncated for scale considerations.

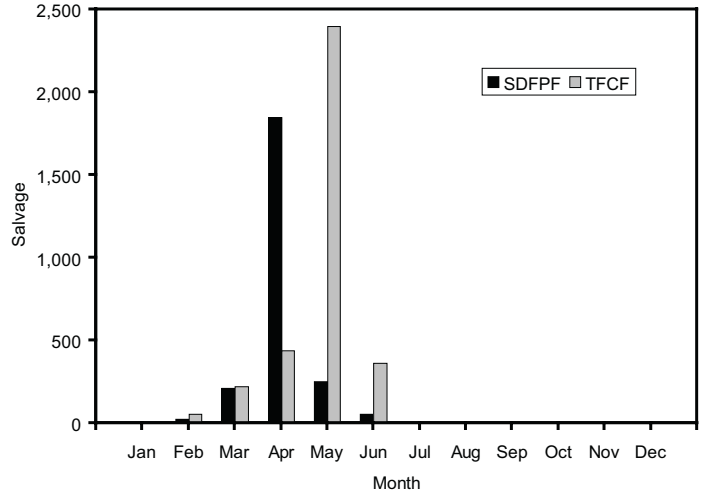

Figure 12 Monthly salvage of wild, spring run Chinook salmon at the SDFPF and the TFCF, 2006

Loss of salmon in 2006 was higher at the SDFPF than at the TFCF (Table 1). At the SDFPF the loss of salmon was estimated at 38,227 while at the TFCF the estimated loss was 23,508. The primary reason for this is the higher mortality associated with Clifton Court Forebay. The losses estimated at each facility parallel the salvage at each facility (Table 1).

Table 1 Annual salvage, percentage of annual salvage, Chinook salmon by race and origin (wild, hatchery, or unknown) and loss of at the SDFPF and the TFCF, 2006

Facility	Origin	Race	Salvage	Percentage	Loss[1]
SDFPF					
	Wild				
		Fall	5,444	63	24,362
		Late-fall	2	<1	9
		Spring	2,366	27	10,282
		Winter	480	6	2,135
	Total Wild		8,292		36,788
	Hatchery				
		Fall	112	1	510
		Late-fall	9	<1	40
		Spring	45	1	204
		Winter	153	2	685
	Total Hatchery		319		1,439
	Unknown		18	<1	
	Grand Total		8,629		38,227
TFCF					
	Wild	Fall	28,841	82	18,863
		Late-fall	12	<1	8
		Spring	*3,456*	*10*	*2,720*
		Winter	*519*	*1*	*337*
	Total Wild		*32,828*		*21,928*
	Hatchery				
		Fall	*1,323*	*4*	*912*
		Late-fall	*12*	*<1*	*8*
		Spring	*556*	*2*	*428*
		Winter	*204*	*1*	*132*
	Total Hatchery		*2,095*		*1,480*
	Unknown		*396*	*1*	
	Grand Total		*35,319*		*23,508*

1. Loss is not calculated for fish of unknown origin.

Results suggest different sizes of wild salmon were salvaged between the 2 facilities (Table 2). Testing was not done on late-fall (wild or hatchery) or hatchery spring run due to small sample sizes (Table 2). The SDFPF salvaged significantly larger winter run salmon ($t = 3.00$, $p = 0.0032$, $df = 139$) while the TFCF salvaged significantly larger fall and spring run salmon (fall: $t = -3.97$, $p < 0.0001$, $df = 2,281$; spring: $t = -8.57$, $p < 0.0001$, $df = 775$)

Table 2 Minimum length, mean length, maximum length, and sample size by origin and race for Chinook salmon salvaged by the SDFPF and the TFCF, 2006. With the exception of sample size, all lengths are in millimeters, FL. An asteisk beside a mean length indicates a significant difference in mean length between the 2 facilities for that origin or race.

Facility	*Origin*	*Race*	*Mean Length*[1]	*Min. Length*	*Max. Length*	*n*
SDFPF						
	Wild					
		Fall	*89	30	121	701
		Late-fall[1]	169	142	195	2
		Spring	*98	65	129	453
		Winter	*137	76	198	95
	Hatchery					
		Fall	100	89	112	18
		Late-fall[1]	174	156	216	4
		Spring[1]	102	93	121	8
		Winter	138	104	208	37
TFCF						
	Wild					
		Fall	*92	30	125	1,582
		Late-fall[1]	139	n/a	n/a	1
		Spring	*105	55	130	324
		Winter	*127	98	182	46
	Hatchery					
		Fall	99	78	114	86
		Late-fall[1]	165	143	186	2
		Spring[1]	112	94	132	40
		Winter	127	100	173	17

1. Difference in means test not given due to small sample sizes at either facility.

A difference in variances was suggested was for spring run fish (F = 1.23, p = 0.0440, df, numerator = 323, df, denominator = 452). Log transforming the spring run data did help the situation (F = 1.39, p = 0.0014, df, numerator = 323, df, denominator = 452). No significant differences in mean length were observed for hatchery salmon: fall, t = 1.07, p = 0.4804, df = 102; winter, t = 1.65, p = 0.1044, df = 52.

Steelhead

The annual salvage of steelhead (all origins combined) at both facilities continued to be low in 2006 (Figure 13). Annual salvage at the SDFPF in 2006 was less than in 2005; 1,287 as compared to 2,196. The reverse was observed at the TFCF as the annual salvage in 2006 was greater than in 2005; 2,516 as compared to 1,347.

The majority of steelhead salvaged at the SDFPF were wild while at the TFCF the majority of steelhead salvaged were hatchery. At the SDFPF the salvage breakdown was: wild – 919, hatchery – 350, unknown origin – 18. At the TFCF the salvage breakdown was: wild – 688, hatchery – 1,828, unknown origin – 0.

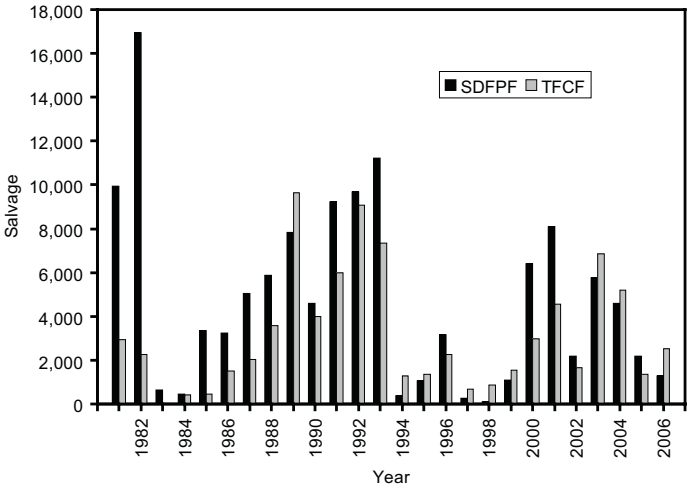

Figure 13 Annual salvage of steelhead (all origins combined) at the SDFPF and the TFCF, 1981 - 2006

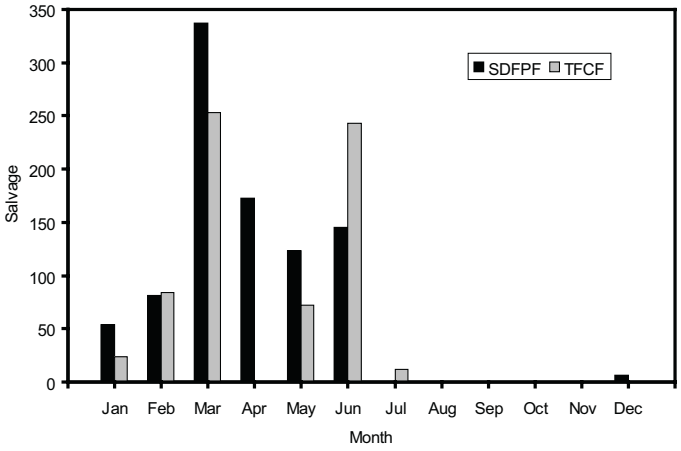

Figure 14 Monthly salvage of wild steelhead at the SDFPF and the TFCF, 2006

Wild steelhead salvage occurred over a greater part of the year than that of hatchery steelhead. Most salvage of wild steelhead occurred in the first half of the year for both facilities. Wild steelhead were salvaged from January – June (again in December) at the SDFPF and from January – March and May – July at the TFCFF (Figure 14). At the SDFPF hatchery steelhead were salvaged in: February (117), March (198), April (26), and June (9). For the TFCF, steelhead were salvaged in: February (240), March (1,587), and April (1).

Results are suggestive that different sizes of hatchery steelhead were salvaged at each facility but results are not suggestive that different sizes of wild steelhead were salvaged (summary statistics are in Table 3). The results from the 2 sample t-test for hatchery fish is: $t = 2.02$, $p = 0.0442$, (237 df). The result of the 2 sample t-test for wild fish is: $t = 1.64$, $p = 0.1030$ (220 degrees of freedom).

Table 3 Steelhead Summary Length Statistics - Minimum, maximum, mean lengths (mm, FL) and sample sizes for hatchery and wild steelhead measured at the SDFPF and the TFCF, 2006.

Facility	*Mean*	*Minimum*	*Maximum*	*n*
		Hatchery		
SDFPF	*241*	*130*	*400*	*70*
TFCF	*230*	*104*	*345*	*169*
		Wild		
SDFPF	*271*	*170*	*520*	*167*
TFCF	*258*	*127*	*423*	*55*

Delta Smelt

Very few delta smelt were salvaged by either facility in 2006, continuing the decline in salvage that started in 2002 (Figure 15). At the SDFPF the annual salvage in 2006 was 24 (a new record low), markedly less than the 2005 annual salvage of 2,922. At the TFCF the annual salvage in 2006 was 312, less than half the annual salvage in 2005 of 818.

Delta smelt were salvaged in only a few months in 2006. At the SDFPF delta smelt were salvaged in January (12) and April (12). At the TFCF delta smelt were salvaged in January (24), February (72) and March (216).

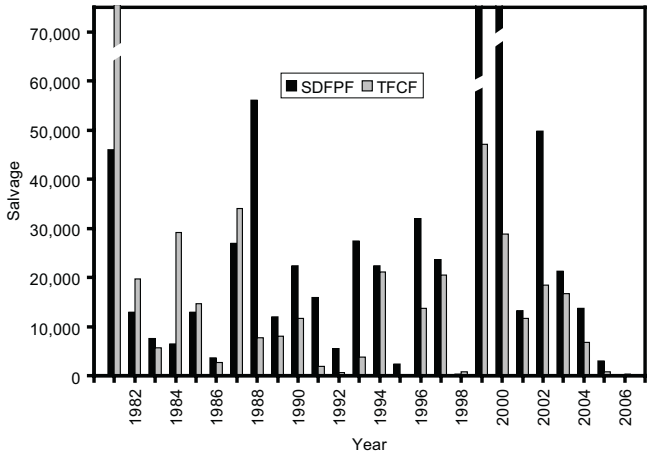

Figure 15 Annual salvage of delta smelt at the SDFPF and the TFCF, 1981 - 2006. The annual salvages in 1999 (107,640) and 2000 (85,188) at the SDFPF have been truncated for scale considerations. The annual salvage of 274,288 in 1981 at the TFCF has been truncated for scale considerations.

Salvaged delta smelt did not differ in size between the facilities, and all were adults. Additional delta smelt were collected incidentally at the SDFPF during the Capture, Handling, Transportation, and Release (CHTR) study. These fish did not count towards salvage as they were collected during non-routine activities but their length data have been included for this analysis. At the SDFPF delta smelt lengths ranged from 56 – 77 mm FL with a mean of 70 mm FL (n = 28). At the TFCF delta smelt lengths ranged from 57 – 77 mm FL with a mean of 72 mm FL (n = 27). Delta smelt did not significantly differ in mean lengths between the 2 facilities ($t = -1.15$, $p = 0.2553$, 53 df).

Green Sturgeon

Relatively large numbers of green sturgeon were salvaged in 2006: 39 at the SDFPF and 324 at the TFCF. Salvage of green sturgeon has been relatively low in recent years (Figure 16).

Green sturgeon were salvaged only in specific months at both facilities. At the SDFPF green sturgeon were salvaged in January (6), July (6), September (12) and December (15). At the TFCF green sturgeon were salvaged from June – December with monthly salvage ranging from 12 – 96.

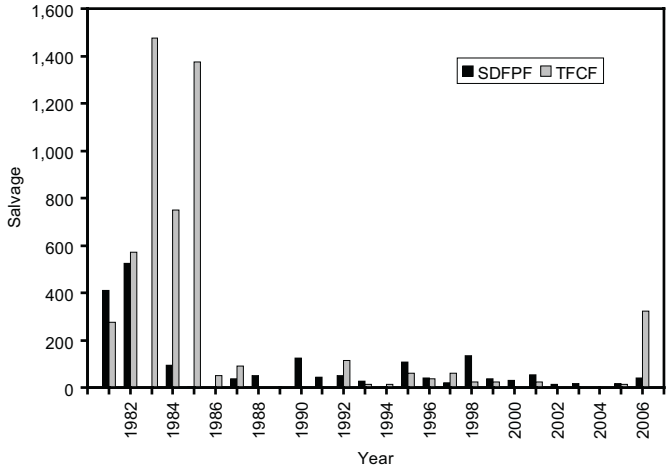

Figure 16 Annual salvage of green sturgeon at the SDFPF and the TFCF, 1981 - 2006

The SDFPF salvaged larger green sturgeon than the TFCF. At the SDFPF green sturgeon lengths ranged from 280 – 540 mm TL with a mean of 388 mm TL (n = 5). At the TFCF green sturgeon lengths ranged from 125 – 400 mm TL with a mean of 248 mm TL (n = 25). No statistical testing was done given the small sample size at the SDFPF.

Splittail

The annual salvage of splittail was higher for both facilities in 2006 than in 2005, and 2006 numbers at both facilities were exceptionally high (Figure 17). At the SDFPF the 2006 annual salvage was 417,859 as opposed to 102,308 in 2005. At the TFCF the 2006 annual salvage was 5,002,611 (a record high), and a dramatic increase from the 2005 value of 342,595. However, large salvages (greater than 150,000) are not uncommon and have been seen in 1982, 1983, 1986, 1995, 1998, 2005, and 2006 (Figure 17).

Almost all of the splittail salvaged by both facilities in 2006 occurred during May – July. At the SDFPF, the combined salvage of May (13,034), June (285,229) and July (116,097) accounted for 99% of the annual salvage. Monthly salvage outside of the above time frame ranged from 7 – 3,118. At the TFCF, the combined salvage of May (231,858), June (4,565,037), and July (205,032) accounted for 99.99% of the annual salvage. Salvage outside the above time frame ranged from 0 – 576.

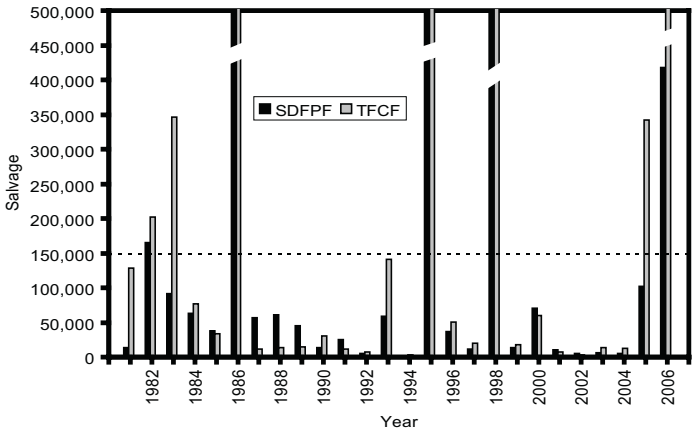

Figure 17 Annual salvage of Sacramento splittail at the SDFPF and the TFCF, 1981 - 2006. The annual salvages at the SDFPF for the following years have been truncated for scale considerations: 1986 (1,160,305), 1995 (2,190,517), and 1998 (1,042,239). The annual salvages at the TFCF for the following years have been truncated for scale considerations: 1986 (1,231,283), 1995 (3,143,156), 1998 (2,051,660), and 2006 (5,002,611).

The TFCF salvaged slightly larger splittail then the SDFPF and that the majority of splittail salvaged at both facilities were young-of-the-year. At the SDFPF splittail lengths ranged from 20 – 350 mm FL with a mean of 46 mm FL (n = 4,935) and the 99th percentile estimated at 85 mm FL. At the TFCF splittail lengths ranged from 20 – 350 mm FL with a mean of 48 mm FL (n = 4,891) and the 99th percentile estimated at 85 mm FL. The variance ratio test suggested that the variances were unequal ($F = 1.48$, $p < 0.0001$, df, numerator = 4,934, df, denominator = 4,890). Length data were transformed using natural logs to normalize distributions, equalizing the variances ($F = 1.00$, $p = 0.8622$, df, numerator = 4,934, df, denominator = 4,890). Results of the 2 sample t-test (transformed data) are $t = -10.59$ ($df = 9,824$), $p < 0.0001$.

Longfin Smelt

No longfin smelt were salvage at either facility in 2006; annual salvages in 2005 were 183 at the SDFPF and 36 at the TFCF (Figure 18). Low or zero annual salvages of longfin smelt are not unknown, and are associated with high outflow years. The 2006 annual salvage of 0 at the SDFPF is new record low for the recent period (the previous low was 52 in 1982) but not for the TFCF were no longfin smelt were salvaged in 1982 and 1995. Large (greater than 10,000) annual salvages of longfin smelt have also been observed at one or both facilities in: 1984, 1985, 1987-1990, and 2002 (Figure 18). Longfin smelt tend to be "boom and bust" in terms of salvage (Figure 18).

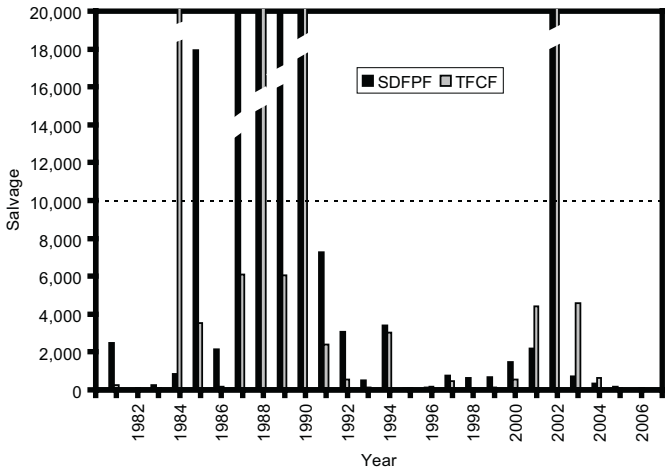

Figure 18 Annual salvage of longfin at the SDFPF and the TFCF, 1981 - 2006. The annual salvages in following years at the SDFPF were truncated for scale considerations: 1987 (50,753), 1988 (140,040), 1989 (61,509), 1990 (26,257), and 2002 (54,606). The annual salvages in 1984 (22,535) and 2002 (43,080) at the TFCF were truncated for scale considerations.

White Sturgeon

Annual salvage of white sturgeon in 2006 was low for both facilities: 23 for the SDFPF and 1 for the TFCF (Figure 19). These annual salvages are not uncommonly low for the period of record as no white sturgeon were salvaged by the SDFPF in 2003 or 2004 or by the TFCF in 1988 – 1991, 1994, 2002, or 2005. Annual salvage of white sturgeon as occurred in 2 large pulses: from 1981 – 1987 and from 1995 – 1998 (Figure 19). Relatively large annual salvages have occurred, notably in 1982 and 1983 at the SDFPF (Figure 19).

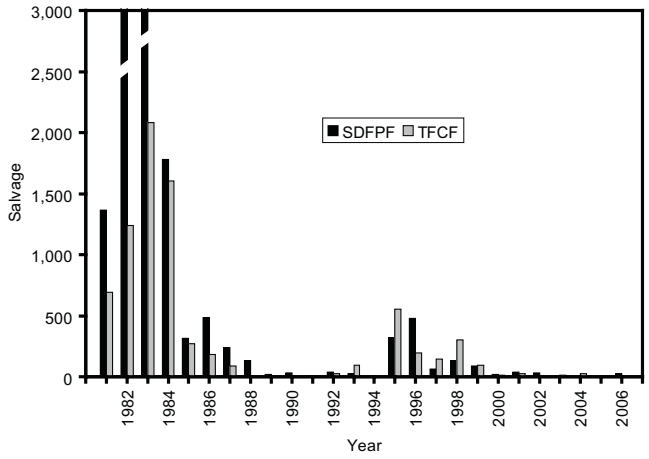

Figure 19 Annual salvage of white sturgeon at the SDFPF and the TFCF, 1981 - 2006. The annual salvages in 1982 (10,806) and 1983 (3,177) at the SDFPF have been truncated for scale considerations.

White sturgeon were salvaged only in certain months in 2006. At the SDFPF white sturgeon were salvaged in: January (6), July (7), August (1), October (3), and November (6). At the TFCF white sturgeon were salvaged in October (1) only.

Due to small sample sizes, no statistical testing was done using white sturgeon length data. At the SDFPF, white sturgeon lengths ranged from 280 – 428 mm TL with a mean of 336 mm TL (n = 4). At the TFCF, a single white sturgeon was measured, 247 mm TL.

Carp

The annual salvage of carp in 2006 reached record highs at both facilities (Figure 20). At the SDFPF, the 2006 annual salvage was 2,739,126 with the range from 1981 – 2005 being 0 – 27,928. At the TFCF the 2006 annual salvage was 30,495,884 with the range from 1981 – 2005 being 84 – 175,374. Generally, annual salvages of carp are less than 4,000 at both facilities (Figure 20). Annual salvages above 4,000 have occurred in: 1982-1984, 1995, 1998, and 2005-2006 (Figure 20).

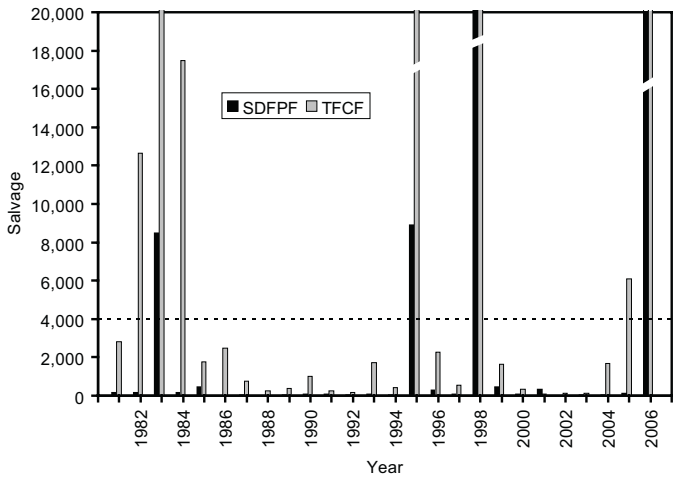

Figure 20 Annual salvage of carp at the SDFPF and the TFCF, 1981 - 2006. The annual salvages in 1998 (27,928) and 2006 (2,739,126) at the SDFPF for the following years have been truncated for scale considerations. The annual salvages at the TFCF for the following years have been truncated for scale considerations: 1983 (109,549), 1995 (75,654), 1998 (175,374), and 2006 (30,495,884).

Almost all of the carp were salvaged in June and July at both facilities. At the SDFPF the June salvage of 2,682,495 and the July salvage of 55,719 accounted for 99.97% of the 2006 annual salvage of carp. At the TFCF, the June salvage of 30,018,630 and the July salvage 463,488 accounted for 99.95% of the annual salvage of carp. Carp were salvaged in every other month except March at the SDFPF and February at the TFCF.

Results suggest larger carp were salvaged at the TFCF however; the assumption of equal variances was violated. Carp salvaged at the SDFPF ranged from 20 – 245 mm FL with a mean of 50 mm FL (n = 2,245) and the 75% percentile estimated at 56 mm FL. Carp salvaged at the TFCF ranged from 20 – 285 mm FL with a mean of 58 mm FL (n = 4,420) and the 75th percentile estimated at 67 mm FL. T-test results are $t = -15.14$, $p < 0.0001$ ($df = 6,663$). The folded form F statistic analysis suggested that the variances were unequal ($F = 4.74$, $p < 0.0001$ df, numerator = 4,419, df, denominator = 2,244). Log transforming of these data did not adequately address this situation ($F = 2.97$, $p < 0.0001$, df, numerator = 4,419, df, denominator = 2,244).

Striped Bass

In 2006, the facilities reported record low or near record low annual salvages of striped bass. The low annual salvages continue the trend in low annual salvage numbers observed since 2000 (Figure 21). At the SDFPF, the 2006 annual salvage was 140,795, just slightly more than the low for the period of record, 131,039 in 1983. At the TFCF, a new low annual salvage of 37,359 was observed. The next lowest annual salvage was observed in 2005, 124,645.

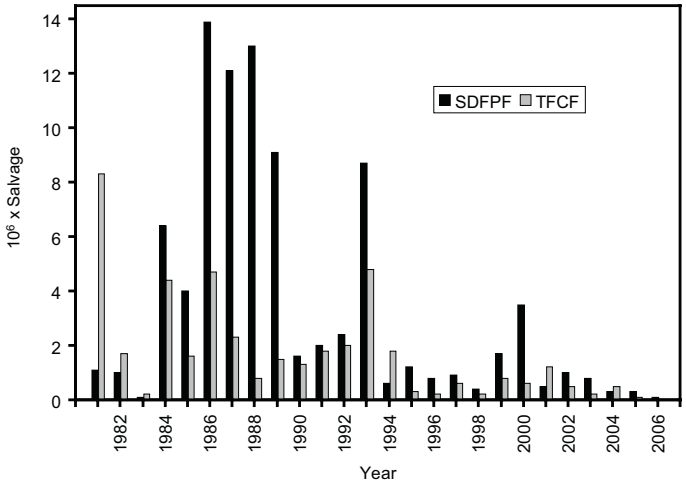

Figure 21 Annual salvage of striped bass at the SDFPF and the TFCF, 1981 - 2006

The months of July and August accounted for the majority of striped bass salvage at both facilities (Figure 22). At the SDFPF the July salvage of 75,220 and the August salvage of 23,522 accounted for 70% of the 2006 annual salvage. At the TFCF the July salvage of 14,016 and the August salvage of 6,511 accounted for 55% of the annual salvage. Striped bass were salvaged every month at both facilities with the lowest monthly salvage in May for both facilities: 253 at the SDFPF and 278 at the TFCF.

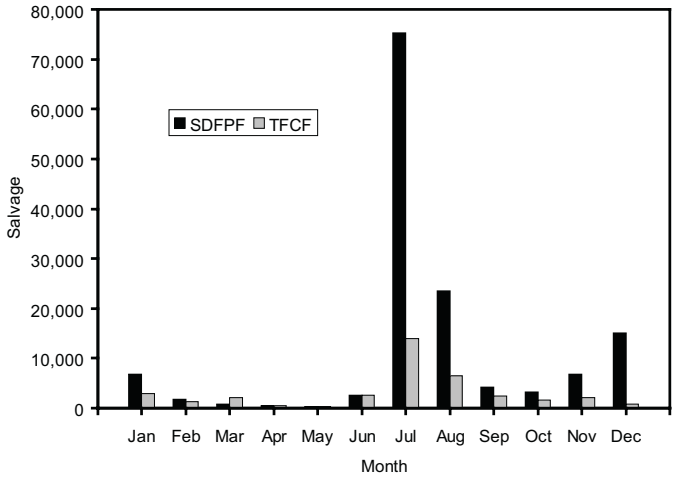

Figure 22 Monthly salvage of striped bass at the SDFPF and the TFCF, 2006

The TFCF caught larger striped bass than the SDFPF and multiple year classes were salvaged however the assumption of equal variances was violated. Striped bass at the TFCF ranged from 20 – 560 mm FL with a mean length of 125 mm FL (n = 924). Striped bass at the SDFPF facility ranged from 20 – 541 mm FL with a mean length of 79 mm FL (n = 3,251). A significant difference for mean length is strongly suggested from the 2-sample t-test ($t = -17.50$, $p < 0.0001$, $df = 4,173$)

The folded form F statistic analysis suggested that the variances were unequal ($F = 2.18$ $p < 0.0001$ df, numerator = 923, df, denominator = 3,250). Log transforming of these data did not adequately address this situation ($F = 1.44$, $p < 0.0001$, df, numerator =923, df, denominator = 3,250).

American Shad

Annual salvage of American shad was lower at both facilities in 2006 as compared to 2005 (Figure 23). At the SDFPF the 2006 annual salvage was 591,252, less than the 1,229,815 American shad salvaged in 2005. At the TFCF the 2006 annual salvage was 151,068, less than the 329,119 American shad salvaged in 2005. The declining trend in American shad salvage observed from 2003 – 2006 at the TFCF was not observed at the SDFPF (Figure 23). Generally, salvage of American shad is higher at SDFPF than at the TFCF (Figure 23).

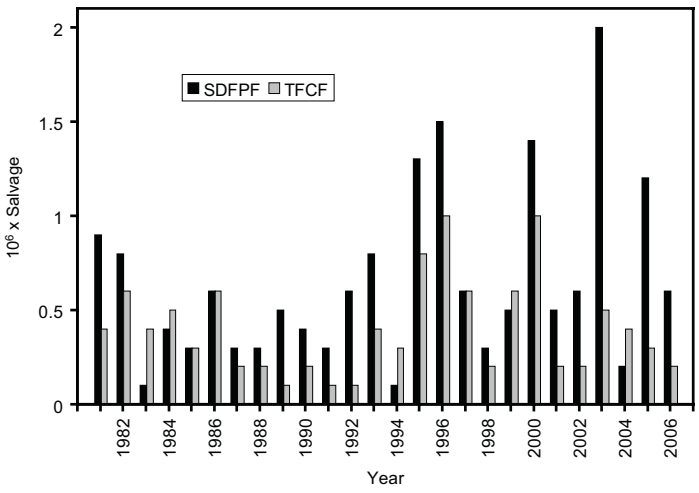

Figure 23 Annual salvage of American shad at the SDFPF and the TFCF, 1981 - 2006

The majority of American shad salvaged in 2006 were salvaged in the last half of the year at both facilities (Figure 24). At the SDFPF monthly salvage ranged from 91 – 216,864 with the salvage from July – December salvage accounting for 96% of the annual salvage. At the TFCF the monthly salvage ranged from 0 – 47,460 with the July – December salvage accounting for 83% of the annual salvage.

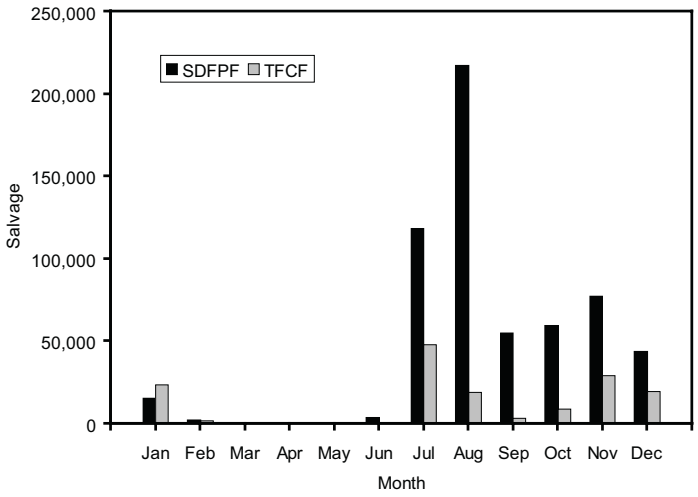

Figure 24 Monthly salvage of American shad at the SDFPF and the TFCF, 2006

Results suggest that the TFCF salvaged larger American shad however; the assumption of equal variances was violated. At the SDFPF American shad ranged from 20 – 405 mm FL with a mean of 65 mm FL (n = 11,587) and the 90th percentile estimated at 97 mm FL. At the TFCF American shad ranged from 20 – 470 mm FL with a mean of 80 mm FL (n = 3,506) and the 90th percentile estimated at 112 mm FL. T-test results are $t = -21.52$ ($df = 15,091$), $p < 0.0001$. The folded form F statistic analysis suggested that the variances were unequal ($F = 1.35$ $p < 0.0001$ df, numerator = 3,505, df, denominator = 11,586). Log transforming of these data did not adequately address this situation ($F = 1.29$, $p < 0.0001$, df, numerator = 3,505 df, denominator = 11,586). The large range of lengths at both facilities suggests multiple year classes of American shad were salvaged.

Threadfin Shad

Annual salvage of threadfin shad at both facilities was lower in 2006 than in 2005, but neither was a record low (Figure 25). At the SDFPF the 2006 annual salvage was 857,140, less than the 2005 annual salvage of 1,183,267. At the TFCT the 2006 annual salvage was 717,112, less than the 2005 salvage of 1,111,569. The record low for both facilities occurred in 1989: 133,755 for the SDFPF and 182,112 for the TFCF.

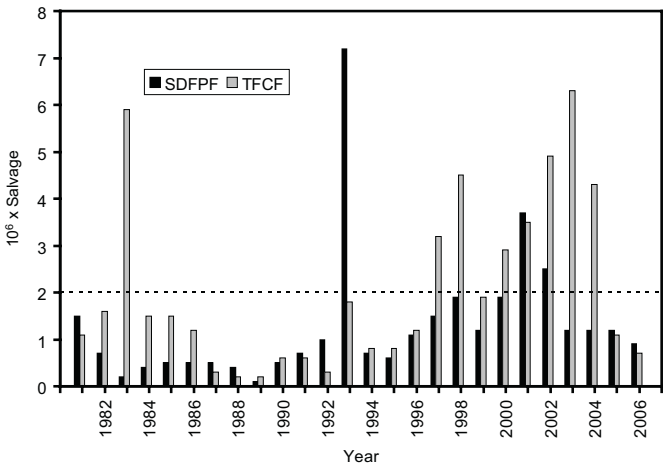

Figure 25 Annual salvage of threadfin shad at the SDFPF and the TFCF, 1981 - 2006

Annual threadfin shad salvage values over 2 million are historically the exception and not the rule. At the TFCF, 8 years out of 26 had annual salvages over 2 million. At the SDFPF only 3 years out of 26 had annual salvages over 2 million. The majority of annual salvages

over 2 million occurred in years since 2000 and at the TFCF (Figure 25).

The majority of threadfin shad were salvaged in the summer months (Figure 26). At the SDFPF the July – September salvage accounted for 89% of the annual salvage. At the TFCF the June – September salvage accounted for 76% of the annual salvage.

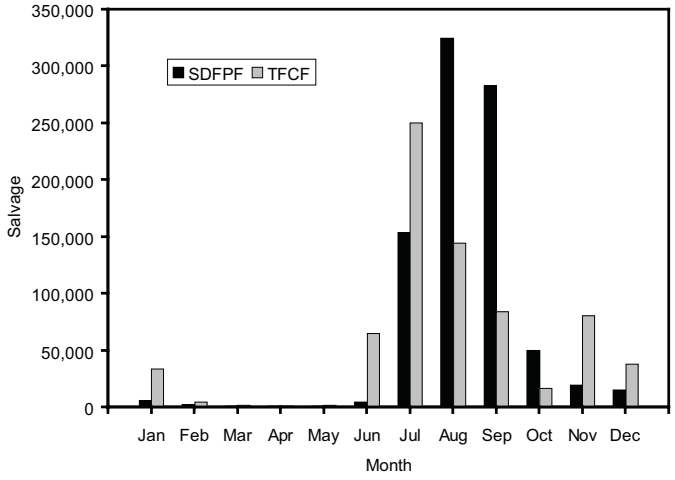

Figure 26 Monthly salvage of threadfin shad at the SDFPF and the TFCF, 2006

Results suggest that larger threadfin shad were salvaged at the TFCF however the assumption of equal variances was violated. At the SDFPF the threadfin shad lengths ranged from 20 -191 mm FL with a mean length of 56 mm FL (n = 11,921) with the 99th percentile estimated at 98 mm FL. At the TFCF threadfin shad lengths ranged from 20 – 192 mm FL with a mean length of 64 mm FL (n = 8,670) with the 99th percentile estimated at 115 mm FL. The 2 sample t-test results are t = -26.45 (df = 20,589), $p < 0.0001$. The folded form F statistic analysis suggested that the variances were unequal ($F = 1.73$ $p < 0.0001$ df, numerator = 8,669, df, denominator = 11,920). Log transforming of these data did not adequately address this situation ($F = 1.51$, $p < 0.0001$, df, numerator = 8,669 df, denominator = 11,920). Threadfin shad lengths greater than 200 mm FL (2 at the SDFPF and 4 at the TFCF) were excluded from the analysis.

Inland Silversides

Annual salvage of inland silversides (silversides) increased at the SDFPF and decreased at the TFCF in 2006 (Figure 27). The 2006 annual salvage at the SDFPF was 52,978 as compared to 18,162 in 2005. The 2006 annual salvage at the TFCF was 18,809 as compared to 22,686 in 2005.

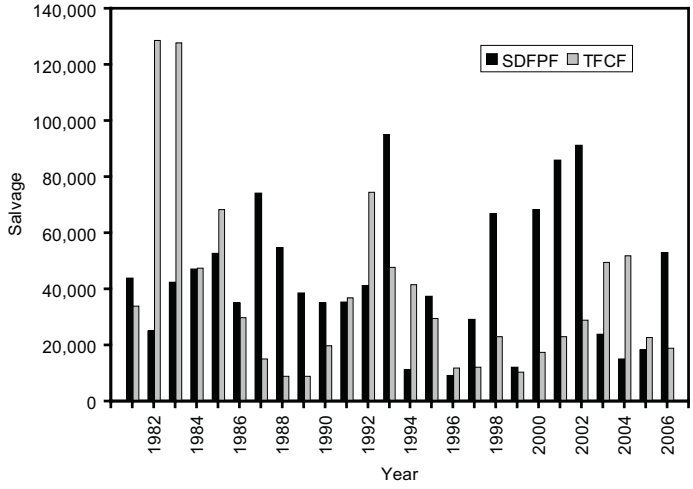

Figure 27 Annual salvage of inland silversides at the SDFPF and the TFCF, 1981 - 2006

The majority of silversides salvage occurred in July at both facilities (Figure 28). At the SDFPF, the July salvage of 36,695 accounted for 69% of the annual salvage. Excluding July, monthly salvage at the SDFPF ranged from 27 to 5,821. At the TFCF, the July salvage of 10,560 accounted for 56% of the annual salvage. Excluding July, monthly salvage at the TFCF ranged from 81 to 2,124.

Results suggest that TFCF salvaged larger silversides than the SDFPF however the assumption of equal variances was violated. At the SDFPF silversides lengths ranged from 20 – 98 mm FL with a mean of 39 mm FL (n = 1,633).

At the TFCF silversides lengths ranged from 20 – 102 mm FL with a mean of 46 mm FL (n = 378). Results of the 2 sample t-test are t = -7.21 (df = 2,009), $p < 0.0001$. The folded form F statistic analysis suggested that the variances were unequal ($F = 1.72$ $p < 0.0001$ df, numerator = 377, df, denominator = 1,632). Log transforming of these data did not adequately address this situation ($F = 1.54$, $p < 0.0001$, df, numerator = 377 df, denominator = 1632).

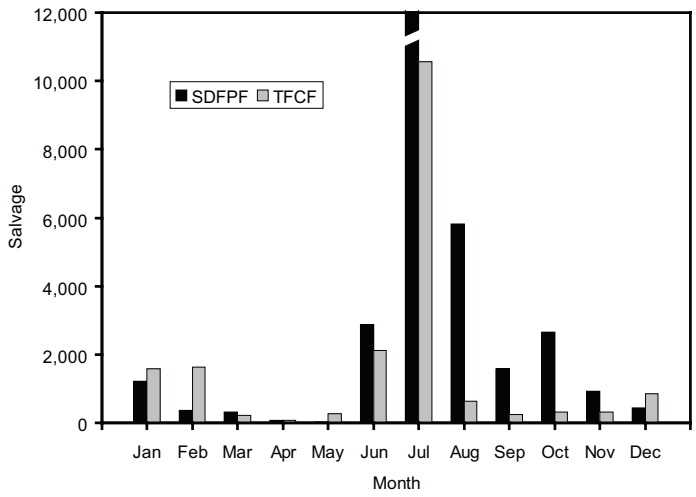

Figure 28 Monthly salvage of inland silversides at the SDFPF and the TFCF, 2006. The July salvage of 36,695 at the SDFPF has been truncated for scale considerations

Chinese Mitten Crabs

Only 12 mitten crabs were salvaged in 2006, all at the TFCF. No length or sex data is available. With the exception of 2001, mitten crab annual salvage has declined since 1999.

REFERENCES

Ramsey, F.L. and Schafer, D.W. 2002. The Statistical Sleuth a Course in Methods of Data Analysis. Duxbury Thomson Learning, United States. 742 pages.

SAS Institute, Inc. 1989. SAS/STAT User's Guide, Version 6, Volume 2. SAS Institute, Inc., Cary, North Carolina. 846 pages.

CENTRAL VALLEY CHINOOK SALMON CATCH AND ESCAPEMENT

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In 2006, the ocean catch of Central Valley Chinook salmon south of Point Arena, California decreased in both the commercial and recreational fisheries to the lowest level in the 1970-2006 period of record. The catch per unit effort (CPUE) statewide also decreased to the lowest level since 1993.

The total escapement of Central Valley Chinook salmon was also the lowest since 1998 but remained above the average escapement for the 1970-2006 period of record. In 2006, the fall-run Chinook escapement to the Sacramento River system decreased from 2005 but was the greatest contributor to the Central Valley fall-run escapement. Spring-run total escapement to Mill, Deer, and Butte creeks also decreased from 2005 to 2006 while winter-run escapement increased slightly between 2005 and 2006 based on the mark-recapture carcass survey estimate.

Central Valley Chinook Ocean Harvest Index and Ocean Catch

The Pacific Fisheries Management Council (PFMC) sets spawner escapement goals for Sacramento River system fall-run Chinook and Klamath River fall-run Chinook. They also develop harvest regulations to protect listed Central Valley winter and spring-run Chinook. These include setting minimum size limits, gear restrictions and season restrictions south of Point Arena. In 2006, the PFMC did not have any specific restrictions for Central Valley fall-run since projected escapement exceeded the upper end of the conservation objective range (PFMC 2007). The restrictions for Sacramento River winter-run and Central Valley spring-run Chinook were similar to 2005. In 2006, the Northern California Coast Chinook escapement was projected to be below the minimum spawner escapement under the Klamath River Fall Chinook conservation objective; so, the PFMC adopted regulations that restricted harvest in California and Oregon (PFMC 2007). The combination of these reg-